

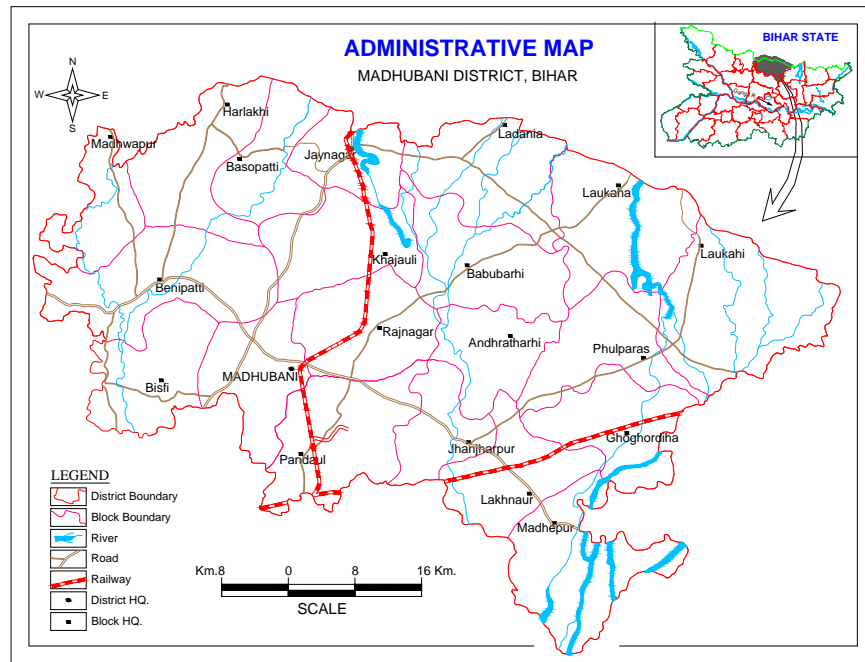


स्वच्छ सुरक्षित जल – सुन्दर खुशहाल कल

**CONSERVE WATER - SAVE LIFE**



# “Ground Water Information Booklet” Madhubani District, Bihar State



**Central Ground Water Board**  
Ministry of Water Resources  
(Govt. of India)  
Mid-Eastern Region  
PATNA

June, 2009

|                             |   |   |
|-----------------------------|---|---|
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**GROUNDWATER INFORMATION BOOKLET  
MADHUBANI DISTRICT**

**DISTRICT AT A GLANCE**

| <b>Sl. No.</b> |   | <b>Statistics</b>  |
|----------------|---|--|
| <b>1.</b>      | <b>GENERAL INFORMATION</b>  |  |
|                | District Headquarter  | Madubani   |
|                | Location  | 26 <sup>0</sup> 03' to 26 <sup>0</sup> 40' N<br>85 <sup>0</sup> 45' to 86 <sup>0</sup> 45' E |
|                | Geographical Area (Sq. Km.)   | 3501 sq.km   |
|                | Administrative Divisions (As on 2009)   | Madhubani, Benipatti,<br>Jhanjharpur, Phulparas,<br>Jaynagar                                 |
|                | No. of Blocks   | 20   |
|                | No. of Panchayats/Villages  | Na/ 1032   |
|                | Population (As per 2001 Census)   | 3,575,281  |
|                | Population Density  | 1021   |
|                | Decadal growth rate   | 26.24  |
|                | Literacy rate   | 41.97  |
| <b>2.</b>      | <b>CLIMATE AND RAINFALL</b>   |  |
|                | Average Annual Rainfall (mm)  | 1289 mm  |
|                | Maximum Temperature   | 42 <sup>0</sup> C  |
|                | Minimum temperature   | 13 <sup>0</sup> C  |
| <b>3.</b>      | <b>GEOMORPHOLOGY</b>  |  |
|                | Major Physiographic Units   | Alluvium   |
|                | Major Drainages   | Kosi Dhar, Bhitahi Balan,<br>Kamla Balan, Dhaus Nadi   |
| <b>4.</b>      | <b>LAND USE (As per 1998-99)</b>  |  |
|                | a) Forest Area  | Nil  |
|                | b) Net Area Sown  | 2251.13 sq.km  |
|                | c) Cultivable Area  | 3170.83 sq.km  |
|                | d) Multi- crop area   | 919.70 sq. km  |
| <b>5.</b>      | <b>MAJOR SOIL TYPES</b>   | Younger and Older<br>Alluvium  |
| <b>6.</b>      | <b>AREA UNDER PRINCIPAL CROPS</b>   |  |
| <b>7.</b>      | <b>IRRIGATION BY DIFFERENT SOURCES<br/>(Areas and Number of Structures, As per 1998-99)</b> |  |
|                | Tube wells irrigation   | 411.13 sq.km   |
|                | Other Sources   | 974.38 sq. km  |
|                | Net Irrigated Area  | 1385.51 sq.km  |
|                | Gross Irrigated Area  | 1000 sq.km   |
| <b>8.</b>      | <b>NUMBER OF GROUND WATER MONITERING<br/>WELLS OF CGWB ( As on 31-03-2007)</b>              |  |

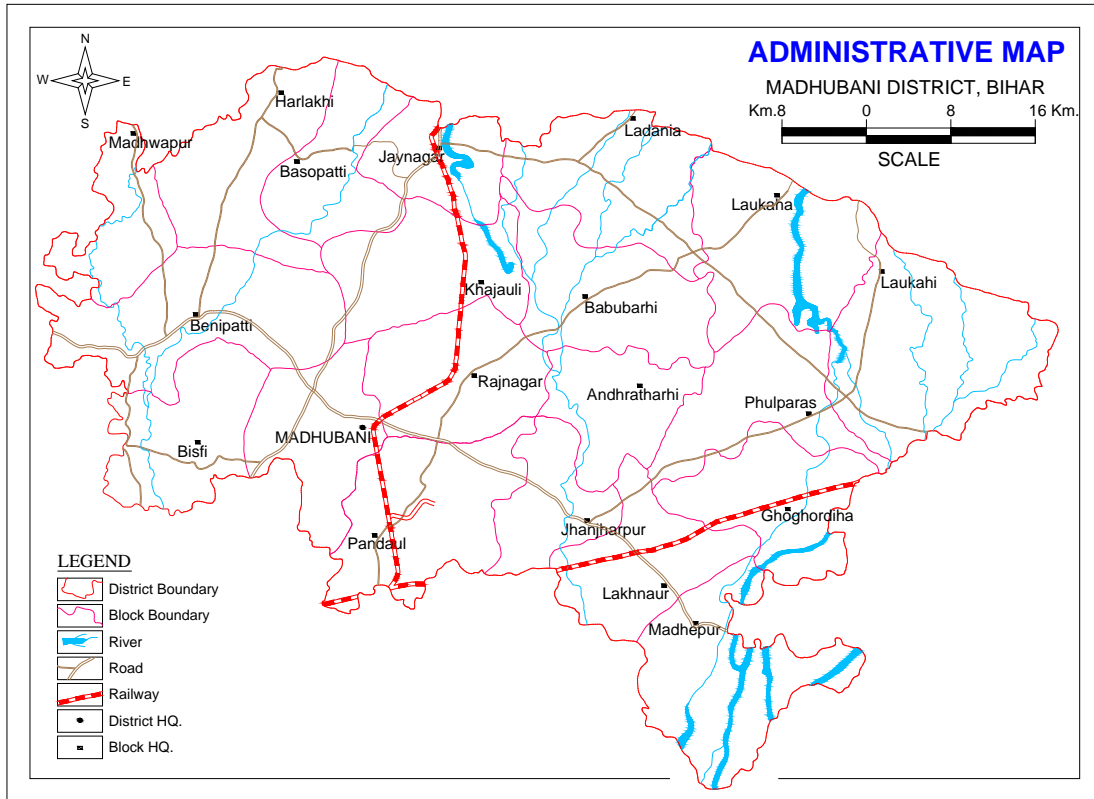
|            |  |   |
|------------|--|---|
|            | No. of Dug wells   | 12  |
| <b>9.</b>  | <b>PREDOMINANT GEOLOGICAL FORMATIONS</b>   | Alluvium  |
| <b>10.</b> | <b>HYDROGEOLOGY</b>  |   |
|            | Major water bearing formations   | Alluvium  |
|            | Pre-monsoon Depth to water level during 2006   | 3 – 7.60 m bgl  |
|            | Post-monsoon Depth to water level during 2006  | < 1 to 4.1 m bgl  |
|            | Long term water level trend in last 10 yrs(1997 – 2006) in m/yr                      | No significant decline  |
| <b>11.</b> | <b>GROUND WATER EXPLORATION BY CGWB (As on 31-03-2007)</b>                           |   |
|            | No. of well drilled (EW,OW, PZ, SH, Total)   | EW-8, PZ-4, OW-11, Total= 23  |
|            | Max. Depth Drilled (m bgl)   | 398.5   |
|            | Max. Depth of Well Construction  | 351   |
|            | Min. Depth of Well Construction  | 112   |
|            | Discharge (m/s)  | 40 – 180 m <sup>3</sup> /hour   |
|            | Storativity (s)  | 1.0 x 10 <sup>-3</sup> to 1.8 x 10 <sup>-4</sup>  |
|            | Transmissivity (m <sup>2</sup> /day)   | 215 – 1736 m <sup>2</sup> /day<br>9.6 – 18 m <sup>3</sup> /hour<br>(autoflow discharge) |
| <b>12.</b> | <b>GROUND WATER QUALITY</b>  |   |
|            | Presence of Chemical constituents more than the permissible limit (e.g.EC, F, As, F) | Fresh & Potable with little higher Iron concentration at places in shallow aquifer      |
|            | Type of Water  |   |
| <b>13.</b> | <b>DYNAMIC GROUND WATER RESOURCES (2004) IN ha.m</b>                                 |   |
|            | Annual Replenishible Ground Water Resources  | 102856  |
|            | Net Annual Ground Water Draft  | 31454.9   |
|            | Projected Demand for Domestic and Industrial Uses up to 2025                         |   |
|            | Stage of Ground Water Development  | 30.6  |
| <b>14</b>  | <b>GROUND WATER CONTROL AND REGULATION</b>   |   |
|            | No. of OE Blocks   | Nil   |
|            | No. of Critical Blocks   | Nil   |
|            | No. of Blocks Notified   | Nil   |
| <b>15</b>  | <b>MAJOR GROUND WATER PROBLEMS AND ISSUES</b>  | No major groundwater related problem  |

## **1.0 INTRODUCTION**

### **1.2 Location, Area and Population**

The district Madhubani lies between the north latitudes of 26<sup>0</sup>03' to 26<sup>0</sup>40' and east longitudes of 85<sup>0</sup>45' and 86<sup>0</sup>44'. It occupies a total geographical area of 3501 sq km. It is bounded by Darbhanga district in the south, Sitamarhi district in the west, Kosi river in the east and Nepal in the north. The is at Madhubani town is the district headquarter of the district and it is well connected by roads to its other towns like Jainagar, Jhanjhapur, Khutauna, Benipatti, Phulparasa etc.

As per the latest 2001 census, the total population of the district stands at 3,575,281 including rural and urban populations of 3,450,336 and 12,45,45 respectively. The decadal population growth rate has been observed to be 26.24%. Madhubani has five Sub-divisions, namely, Madhubani, Jaynagar, Benipatti, Jhanjhapur and Phul Paraas. As on 31<sup>st</sup> March 2004, the district has twenty blocks namely Madhubani, Jainagar, Pandaul, Bisfi, Benipatti, Basopatti, Babubarhi, Rajnagar, Madhepur, Khutauna, Khajauli, Jhanjhapur, Ghoghardiha, Ladania, Madhwapur, Harlakhi, Laukahi, Andharatharhi, Lakhnaur and Phulparas. Paddy is the key crop of the district. Pisciculture is known to be one of the main sources of revenue in the district. Sugar factories are also present in the district, which help in income generation. Madhubani is popular world over for its art and crafts. Madhubani Paintings claim a distinct identity because of their unique design and top quality texture. The district, intersected by Kamala and Bhutahi Balan rivers, is flourishing every year with its farming endeavours and artistic richness.



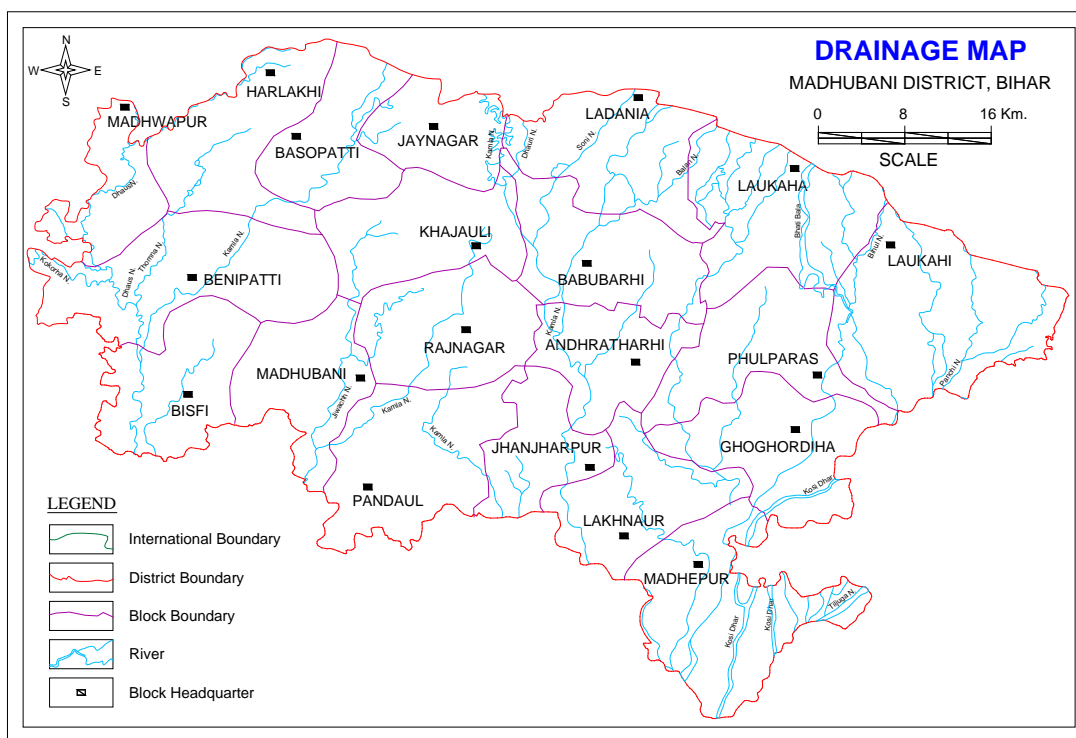
**Figure 1:** Administrative map of Madhubani district, Bihar with block boundaries road (rail) networks

### 1.2 Basin/Sub-Basin and Drainage

The district Madhubani forms a part of Mid-Ganga basin with Kamla Balan sub-basin (Figure 1). The district is situated just to the south of Tarai region of Nepal. The rivers originating from the Tarai zone with their tributaries are flowing towards south and meeting major rivers in India. The principal rivers in Madhubani district from east to west are Kosi Dhar, Bhutahi Balan, Kamla Balan and Dhaus Nadi (Table 1).

**Table 1 Principal Rivers and their Tributaries in Madhubani District**

| Principal rivers | Tributaries   |
|------------------|---|
| Kosi Dhar        | 1. Kosi Dhar<br>2. Kajra<br>3. Kharag               |
| Bhutahi Balan    | 1. Bihul Nadi<br>2. Bhutahi Nadi<br>3. Sugarwe Nadi |
| Kamla Balan      | 1. Sonia Nadi<br>2. Kamla Nadi<br>3. Ziwach Nadi    |
| Dhaus Nadi       | 1. Dhaus Nadi<br>2. Thomana Nadi                    |



**Figure 2:** Drainage map of Madhubani district, Bihar.

#### 1.4 Landuse Pattern, Agriculture and Irrigation Practices

Out of the total geographical area of the district, nearly 65 % (2251 sq.km) is culturable and the rest constitute non-culturable wasteland and land put to non-agricultural uses. There are mainly two harvesting seasons in the district in a year known as Rabi and Kharif. The area under paddy cultivation stands at 36.85 % of the total agricultural land in the district. During the Rabi season (October to April), the crops like wheat, barley and pulses etc are sown, while the main crops during Kharif season (June to October) are paddy, maize, Jawar and pulses. Sugarcane is sown during both the seasons.

The main sources of irrigation in the district are shallow tube wells, tanks and canals. Tanks and canals are basically rain-fed and dry up during the Rabi season.

#### 1.5 Activities Carried out by CGWB

A systematic hydrogeological survey was carried out by CGWB in the district during 1975-76. Again the potential ground water areas in the district were delineated in 1981 through systematic survey. Later on in 1994-95, a hydrogeological reappraisal survey was carried out in order to evaluate the status of ground water development in the district. During 1993-95, a total

23 bore holes were drilled in the district including 8 exploratory wells, 11 observation wells and 4 piezometers, in order to demarcate the auto-flow zone in the district, to decipher the aquifer geometry and their potentiality. The bore hole have been drilled to a maximum depth of 398.5 m. Besides, all these, Central Ground Water Board has a set up of dug wells in the district as Hydrograph Network Stations from which water level data are collected four times in a year in order to study the general ground water trend in the district.

## **2.0 CLIMATE AND RAINFALL**

The district experiences a sub-tropical climate, characterized by tolerable summer (March to November) and pleasant winter (November to February). The maximum and minimum daily temperatures during May are around 36<sup>0</sup>C and 24<sup>0</sup>C respectively. In rare cases, the summer maximum temperature reaches 43<sup>0</sup>C. In winter the temperature varies within 24<sup>0</sup>C and 10<sup>0</sup>C. The maximum humidity in the region is felt during rainy season and minimum in summer.

The normal annual rainfall in the district varies stands at 1257.81 mm, of which monsoon rainfall constitutes about 83.14 % (1045.71 mm). The rain usually starts in the middle of June. The maximum rainfall occurs between the second half of July and first half of August.

**Table 2 Rainfall Pattern in the Madhubani district during 1997-98**

| Duration                | Rainfall (mm) |
|-------------------------|---------------|
| June – September 1997   | 1114.4        |
| October – December 1997 | 15.60         |
| January – February 1998 | 16.70         |
| March – May 1998        | 92.00         |
| Annual 1977-98          | 1338.7        |

## **3.0 GEOMORPHOLOGY AND SOIL TYPES**

The entire Madhubani district is a plain tract situated just to the south of Nepal. The foothills of Nepal Himalayas, which are running east west, is 30 – 35 km north from the Madhubani district border. The entire Tarai zone lies in Nepal with high relief of 2.95 -3.95 m/km and slopping towards south. The northern parts of Madhubani are in touch with the Tarai zone. From the end of the Tarai zone up to the south of the district, the areas shows 1 m/km gradient with ground elevation of 80 m amsl at the northern boundary and 40 m amsl at the southern boundary. Thus the relief of the area in Nepal is much higher in comparison to the area towards its south in Madhubani district.

The area in Madhubani district can be sub-divided three geomorphological units namely (i) Newer Flood Plain, (ii) Older flood plain and (iii) Older alluvial plain. The flood plains are mainly occurring all along the river courses and consist of sand, silt and clay having largely low-lying water logged areas. The old flood plains consist of sand, silt and clay and are mostly under paddy cultivation. The older alluvial plains are generally uplands and consist of clayey silt, clay, and occasional kankars.

### **1.3 Soil**

The soils found in Madhubani district have been classified into the following three categories:

- i) Newer Aluvium (Khadar)
- ii) Sandy Alluvium soil having alkaline reaction
- iii) Calcareous soil

Newer Alluvium soil is generally found along either side of the river namely Kamla, Bhutahi Balan and Dhaus Nadi.

The soils in Madhubani fall in the class of largely entisols with several variations brought about due to vagaries of fluvial sedimentation. These soils have not got sufficient time for pedogenic changes due to highly dynamic fluvial regimes in the area.

## **4.0 GROUND WATER SCENARIO**

### **4.1 Hydrogeology**

The quaternary alluvium is the main repository of ground water in Madhubani district. Granular and mixed zones are found with different thicknesses starting from the depth of 15 m bgl to the explored depth of 398 m bgl.

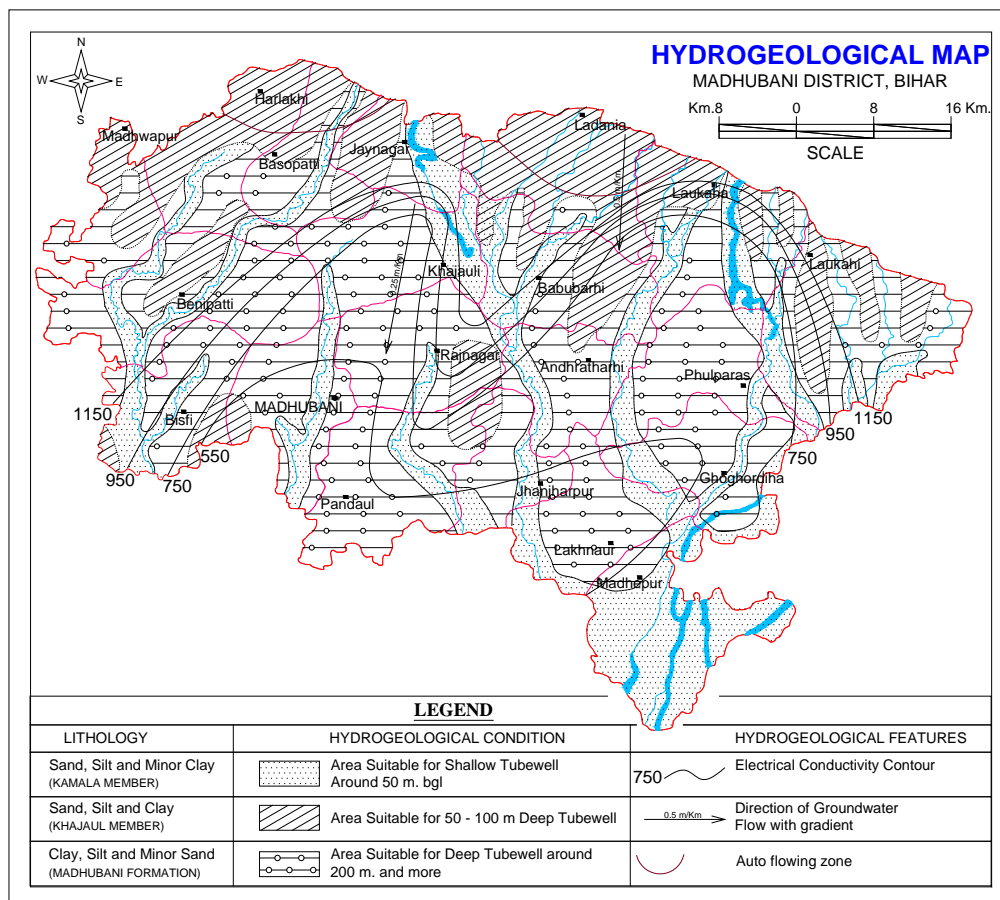
The dug wells are sustained within 15 m bgl, of the formations of predominantly clay, silt and sand lenses. Here, the ground water occurs under water table condition.

In the northern part of the district, in Ladania, Padma and Harlakhi section, the first potential aquifer comes within 15 – 50 m bgl (semi-confined to confined). The local farmers mostly exploit this by constructing shallow tube wells. The next important aquifers come at depth ranges of 129 -146 m bgl, 185-197 m bgl and 305-311 m bgl respectively. All these three aquifers are auto-flowing in nature (Figure 3) with an average discharge of 9.6 m<sup>3</sup>/hr (free flow discharge). This auto-flow nature of the aquifers has developed due to the thick (50 – 129 m bgl)

confining clay layer, which overlies them. The piezometric head of the wells constructed in this zone lies at 1.34 – 2.77 m AGL with the highest free flow discharge of 18 m<sup>3</sup>/hr.

In the remaining parts of the district, the hydrogeological scenario has been quite modified by the fluvial regimes of the rivers in the district. Places close to the rivers show silty and fine sand layers up to a depth of 20 m bgl. Here, water occurs under water table condition. In general a thick clay bed from 10 – 60 m bgl with silt and fine sand bed partings, covers the underlying major aquifers within 60 -110 m bgl as per the state tube well drilling data. These aquifers are under confined condition.

As per the ground water exploration work conducted in the northern part of the district by CGWB, the yield of the wells constructed in this part can be up to 180 m<sup>3</sup>/hr with a safe drawdown of 6 – 12 m. The aquifer test conducted in this part indicates that the transmissivity value of the aquifers varies between  $1.01 \times 10^{-3}$  to  $1.8 \times 10^{-4}$  (confined condition).

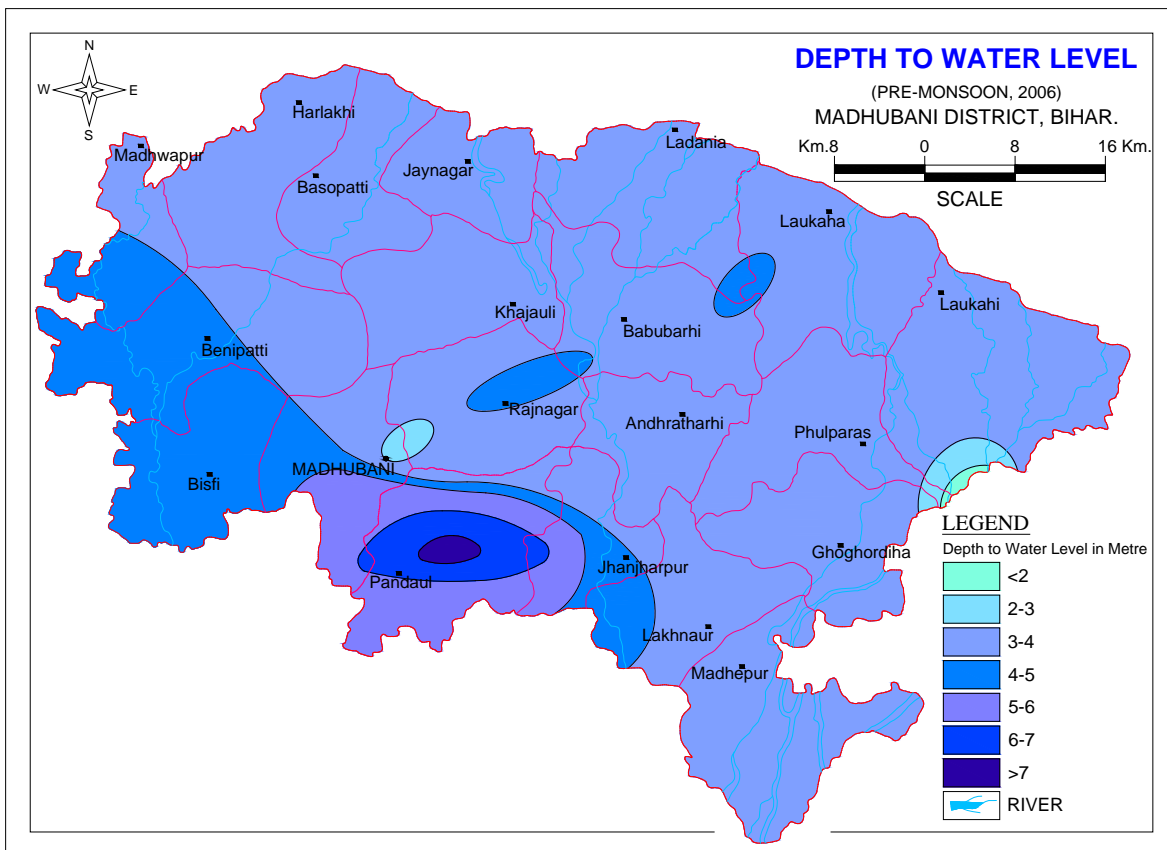


**Figure 3:** Hydrogeological map of Madhubani district, Bihar showing Quaternary Alluvium with their yield potential. Auto- flowing zone has been demarcated by curves around Harlakhi and Ladania. Electrical conductivity of groundwater has been represented by contours.

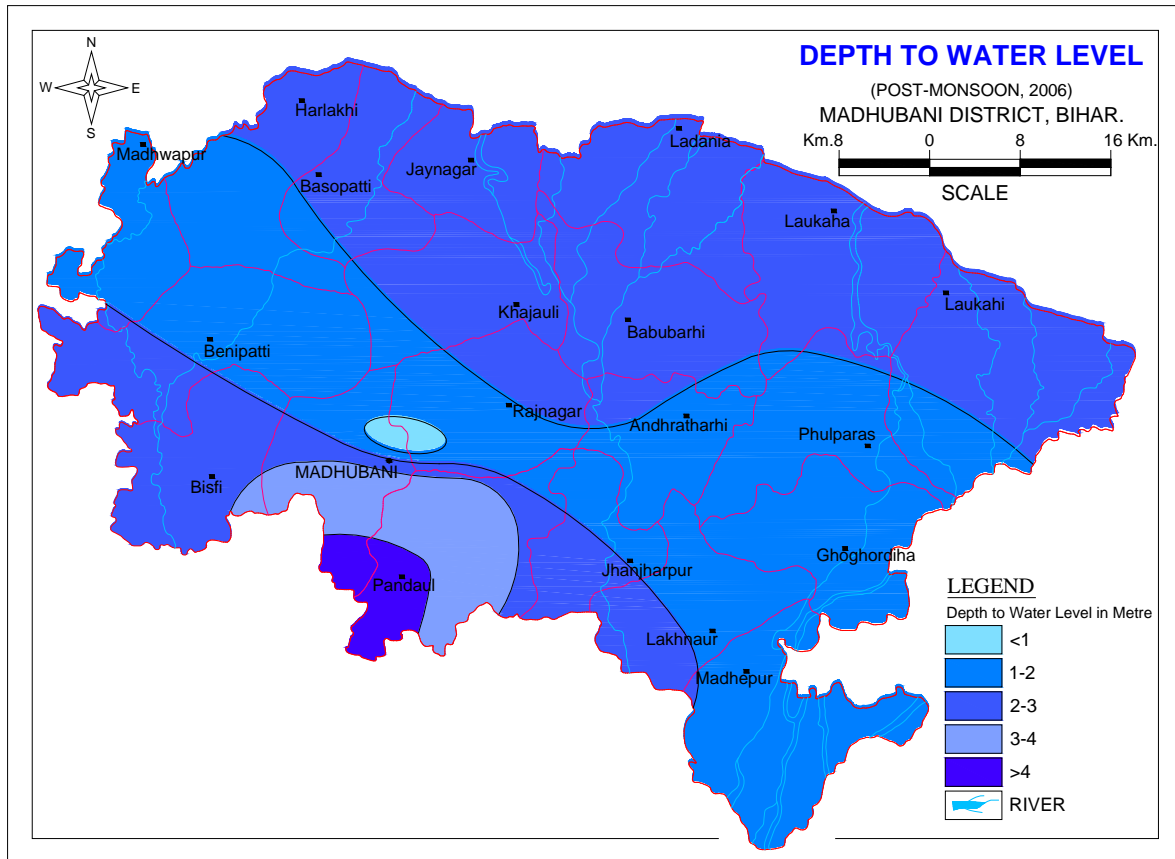
## 4.2 Depth to Water Level

The pre-monsoon depth to water level (DTW) in the district has been found (Figure 4) to be more (4 to < 7) in south and south-western parts covering areas of Pandaul, Bhawanipur, Kapileshwar and Benipatti with the maximum DTW of 7.61 m bgl at Bhawanipur as per 2006 pre-monsoon water level data. In the remaining parts of the district, the pre-monsoon DTW remains within 3 – 4 m bgl except two patches at Khajauli and Khutauna where it lies within 4 – 5 m bgl.

As per the post-monsoon water level data (Figure 5) for the year 2006, in the south and southwestern parts of the district, excluding Benipatti, the DTW varies between 2.0 – 4.1 m bgl. In the northern part, covering Jainagar, Khutauna, Khajauli, Narar and Laukaha etc, the DTW remains within 2 – 3 m bgl. In the remaining central part of the district the post-monsoon DTW is shallower and remains within < 1 to 2 m bgl (Figure 5).



**Figure 4:** Pre- monsoon depth to water level contours in Madhubani district, Bihar.



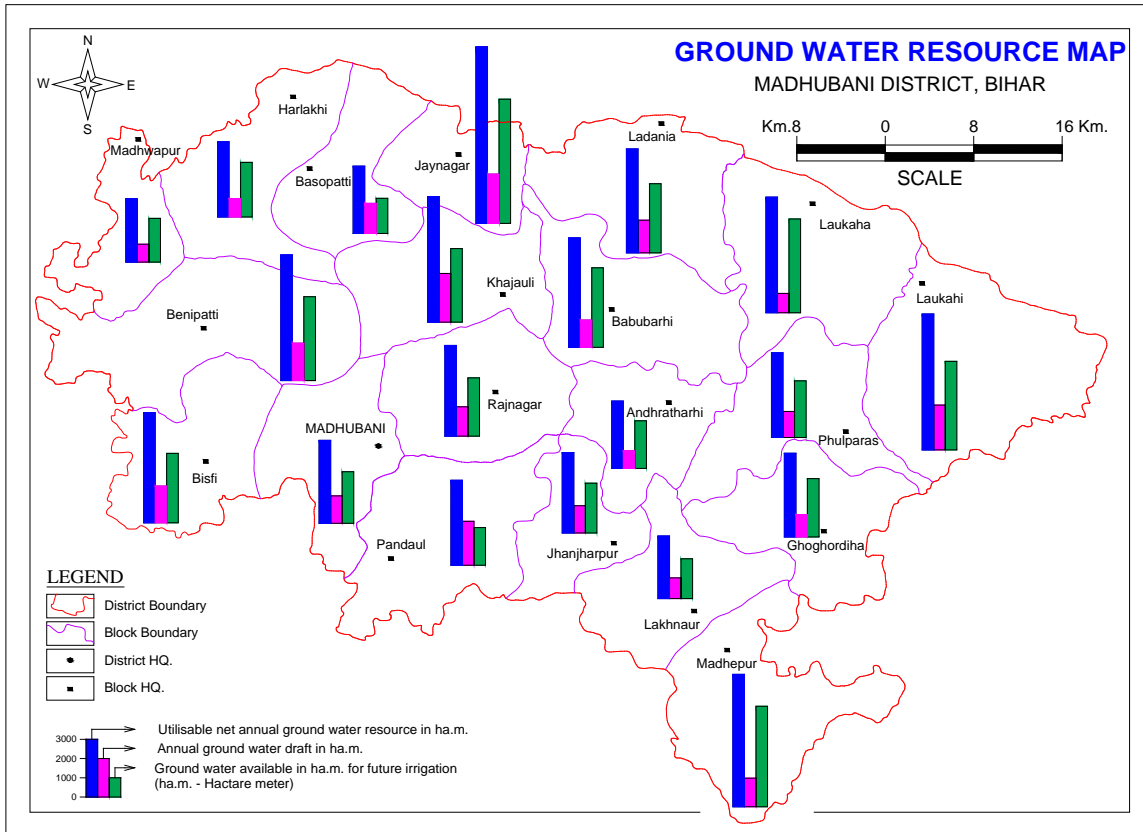
**Figure 5:** Post- monsoon depth to water level contours in Madhubani district, Bihar.

#### 4.2 Ground water Resources

The replenishable groundwater resource estimated (as on 31<sup>st</sup> March-2004) for the district Madhubani is given in Table 3 (also refer figure 6). As per this data, all blocks in the district come under safe category (refer table 4 & figure 7); i. e. the stage of ground water development is below 70 % of the total replenishable (dynamic) resource. The blocks Pandaul and Basopatti have the highest development status (51.7 and 44.7 % respectively) of their total resources available while the block Laukha has the lowest status (only 16.7 %) of development of its total resource. Among all, the block Jainagar possesses highest dynamic ground water resource (6461.5 ha.m) available for future irrigation while the blocks Pandaul and Basopatti are possessing lowest ground water resources (1959 & 1836.4 ha.m respectively) available for future irrigation.

**Table 3 Replenishable ground water resources in the district as on 31<sup>st</sup> March- 2004.**

| Sl. No | Assessment Unit/District | Net Annual Ground water Availability | Existing Gross Ground Water Draft for Irrigation | Existing Gross Ground water Draft for Domestic and Industrial Water Suply | Existing Gross Ground Water Draft For all Uses (10+11) | Allocation for Domestic and Industrial Requirement t suply upto next 25 years | Net Ground Water Availability for future irrigation developme nt (9-10-13) | Stage of Ground Water Development (12/9)*100 (%) |
|--------|--------------------------|--------------------------------------|--|---|--|---|--|--|
| 1      | 2                        | 9                                    | 10   | 11  | 12   | 13  | 14   | 15   |
| 1      | Andaratharhi             | 3498.4                               | 675.7  | 231.2   | 906.9  | 349.4   | 2473.3   | 25.9   |
| 2      | Babubarahi               | 5687.9                               | 1140.3   | 273.7   | 1414.0   | 413.6   | 4134.0   | 24.9   |
| 3      | Basopatti                | 3499.9                               | 1352.1   | 212.7   | 1564.7   | 321.4   | 1826.4   | 44.7   |
| 4      | Benipatti                | 6533.5                               | 1492.0   | 449.0   | 1941.0   | 678.6   | 4362.9   | 29.7   |
| 5      | Bisfi                    | 5725.6                               | 1495.0   | 411.3   | 1906.3   | 621.6   | 3609.0   | 33.3   |
| 6      | Ghoghardiha              | 4349.6                               | 870.7  | 291.9   | 1162.5   | 447.5   | 3031.4   | 26.7   |
| 7      | Harlakhi                 | 3910.2                               | 712.3  | 238.2   | 950.5  | 360.0   | 2837.9   | 24.3   |
| 8      | Jainagar                 | 9184.1                               | 2260.8   | 299.9   | 2560.7   | 461.9   | 6461.5   | 27.9   |
| 9      | Jhanjharpur              | 4184.1                               | 1087.4   | 329.3   | 1416.6   | 508.3   | 2588.4   | 33.9   |
| 10     | Khajauli                 | 6522.5                               | 2203.4   | 327.0   | 2530.4   | 494.2   | 3824.9   | 38.8   |
| 11     | Ladania                  | 5403.8                               | 1481.9   | 216.2   | 1698.2   | 326.8   | 3595.0   | 31.4   |
| 12     | Lakhnaur                 | 3251.7                               | 862.7  | 211.1   | 1073.8   | 319.0   | 2069.9   | 33.0   |
| 13     | Laukaha                  | 6009.4                               | 739.3  | 263.4   | 1002.7   | 398.2   | 4872.0   | 16.7   |
| 14     | Laukahi                  | 7063.6                               | 2071.6   | 255.5   | 2327.0   | 386.1   | 4605.9   | 32.9   |
| 15     | Madhepura                | 6886.2                               | 1143.4   | 342.6   | 1486.0   | 517.7   | 5225.1   | 21.6   |
| 16     | Madhubani                | 4314.9                               | 1028.0   | 394.4   | 1422.4   | 604.8   | 2682.1   | 33.0   |
| 17     | Madhwapur                | 3295.0                               | 750.2  | 178.4   | 928.6  | 269.6   | 2275.2   | 28.2   |
| 18     | Pandaul                  | 4420.5                               | 1942.0   | 343.8   | 2285.8   | 519.6   | 1959.0   | 51.7   |
| 19     | Phulparas                | 4400.6                               | 1146.9   | 204.8   | 1351.7   | 309.5   | 2944.2   | 30.7   |
| 20     | Rajnagar                 | 4714.4                               | 1211.2   | 313.9   | 1525.1   | 474.5   | 3028.7   | 32.4   |
|        | <b>Total</b>             | <b>102856.0</b>                      | <b>25666.8</b>                                   | <b>5788.1</b>   | <b>31454.9</b>   | <b>8782.4</b>   | <b>68406.8</b>   | <b>30.6</b>                                      |

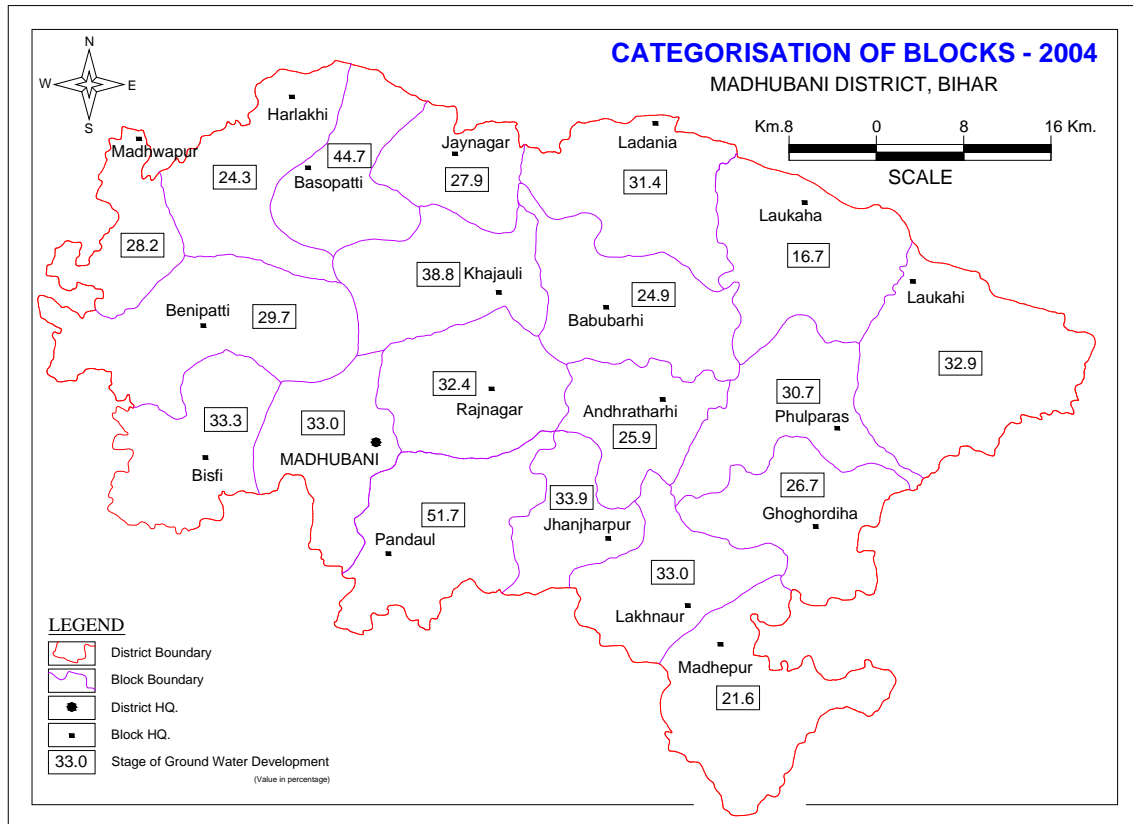


**Figure 6:** Map showing the groundwater resource potential of Madhubani district, Bihar.

**Table 4 Status of Ground Water development in Bhojpur district, Bihar.**

| Sl.No. | District / Assessment Unit | Stage of Ground Water Development (%) | Is there a significant Decline of pre-monsoon water table levels (Yes/No) | Is there a significant Decline of post-monsoon water table levels (Yes/No) | Categorisation for future Ground water Development (safe/semi-critical/critical/over-exploited) |
|--------|----------------------------|---------------------------------------|---|--|---|
| 1      | 2                          | 15                                    | 16  | 17   | 18  |
| 1      | Andaratharhi               | 25.9                                  | No  | No   | Safe  |
| 2      | Babubarahi                 | 24.9                                  | No  | No   | Safe  |
| 3      | Basopatti                  | 44.7                                  | No  | No   | Safe  |
| 4      | Benipatti                  | 29.7                                  | No  | No   | Safe  |
| 5      | Bisfi                      | 33.3                                  | No  | No   | Safe  |
| 6      | Ghoghardiha                | 26.7                                  | No  | No   | Safe  |
| 7      | Harlakhi                   | 24.3                                  | No  | No   | Safe  |
| 8      | Jainagar                   | 27.9                                  | No  | No   | Safe  |
| 9      | Jhanjharpur                | 33.9                                  | No  | No   | Safe  |
| 10     | Khajauli                   | 38.8                                  | No  | No   | Safe  |
| 11     | Ladania                    | 31.4                                  | No  | No   | Safe  |
| 12     | Lakhnaur                   | 33.0                                  | No  | No   | Safe  |

|    |           |      |    |    |      |
|----|-----------|------|----|----|------|
| 13 | Laukaha   | 16.7 | No | No | Safe |
| 14 | Laukahi   | 32.9 | No | No | Safe |
| 15 | Madhepura | 21.6 | No | No | Safe |
| 16 | Madhubani | 33.0 | No | No | Safe |
| 17 | Madhwapur | 28.2 | No | No | Safe |
| 18 | Pandaul   | 51.7 | No | No | Safe |
| 19 | Phulparas | 30.7 | No | No | Safe |
| 20 | Rajnagar  | 32.4 | No | No | Safe |



**Figure 7:** Map showing the stage of groundwater development in the district of Madhubani in Bihar.

### 4.3 Status of Ground Water development

The utilisation of ground water for irrigation in the district can be visualised from the fact that only 38.01 % of the total irrigated area is served by ground water structures based on minor irrigation system.

There are 868 deep tube wells in the district out of which more than 90 % are non-operational due to non-availability of electricity. As per 1992-93 MI census, the district is possessing 13685 shallow tube wells, most of which are diesel engine operated. Though there are

6 canals in the district, those are capable of irrigating hardly 686 hectares because these canals are rainfed in character.

#### 4.4 Ground Water Quality

It has been found that the ground water in the area falls under the permissible limit for both drinking as well as irrigation purposes. Only the iron concentration is found to be crossing the permissible limit (0.3 mg/l) (Table 5). Shallower aquifers contain higher concentration of iron than the deeper aquifers. The following table depicts the extent of the presence of various chemical parameters in ground water of both shallow as well as deeper aquifers in Madhubani district.

**Table 5 Ground water quality (refer figure 3 for contour of EC values in groundwater)**

| Chemical constituents<br>(mg/l)               | Deeper<br>Aquifer | Shallow<br>Aquifer | Drinking Water Standard (As per BIS norms) |                        |
|---|-------------------|--------------------|--|------------------------|
|   |                   |                    | Highest<br>Desirable                       | Maximum Permissible    |
| pH  | 7.0               | 7.42 – 8.91        | 6.5 – 8.5                                  | No relaxation          |
| E.C (Micro-siemens/cm<br>at 25 <sup>0</sup> C | 564 - 734         | 500 - 2000         | 500  | 2000                   |
| Total Hardness (CaCO <sub>3</sub> )           | 235 - 280         | 110 - 380          | 300  | 600                    |
| Bicarbonate                                   | 378 - 445         | 177 - 476          | 200  | 600                    |
| Calcium                                       | 52 - 80           | 12 - 44            | 75   | 200                    |
| Magnesium                                     | 16 - 35           | 12 - 66            | 30   | 100                    |
| Chloride                                      | 3.55 – 10.60      | 14 - 263           | 250  | 1000                   |
| Sulphate                                      | < 1.0             | -                  | 200  | Up to 400 if Mg is <30 |
| Nitrate                                       | < 1.0             | -                  | 45   | 100                    |
| Fluoride                                      | 0.2 – 0.25        | 0.41 – 0.76        | 0.6 – 1.2                                  | 1.5                    |
| Iron  | <0.1 – 3.20       | -                  | 0.30                                       | 1.0                    |
| Sodium  | 22 - 45           | 75 - 246           |  |                        |
| Potassium                                     | 1.40              | 2.70               | 1.90 - 50                                  |                        |

## 5.0 GROUND WATER MANAGEMENT STRATEGY

### 5.1 Ground Water development

The average stage of ground water development in the district stands at 30.6 % only showing its great potential for future irrigation. All the ground water abstraction structures present in the district have created an irrigation potential of 25666.8 ha.m leaving a balance of 68406.80 ha.m of ground water resource potential for future irrigation.

### 5.2 Design of Tube Wells

#### 5.2.1 Sallow Tube Wells

The district is blessed with potential aquifers, which can meet the demand of shallow tube wells (STW) having small command area. The STWs in the depth range of 30 – 50 m bgl and tapping granular zones between 15 - 25 m bgl and 20 – 50 m bgl can yield 25 to 30 m<sup>3</sup>/hr. A well assembly of about 76 to 102 mm diameter with about 10 to 20 m slotted pipe can be used for construction of such wells.

#### 5.2.2 Deep Tube Wells

**Table 6 Proposed Model of Deep Tube Wells**

| Sl.No. | Discharge<br>(m <sup>3</sup> /hr) | Proposed<br>Depth of<br>well (m bgl) | Proposed Diameter of well<br>(mm) | Assembly<br>Length (m) |
|--------|-----------------------------------|--------------------------------------|-----------------------------------|------------------------|
| 1      | 100                               | 100                                  | 306 – casing pipe                 | 25                     |
|        |                                   |                                      | 153 – slotted pipe                | 24                     |
|        |                                   |                                      | 153 – blank pipe                  | 51                     |
| 2      | 150                               | 150                                  | 357 – casing pipe                 | 30                     |
|        |                                   |                                      | 204 – slotted pipe                | 30                     |
|        |                                   |                                      | 204 – blank pipe                  | 90                     |
| 3      | 290                               | 190                                  | 357 – casing pipe                 | 35                     |
|        |                                   |                                      | 204 – slotted pipe                | 35                     |
|        |                                   |                                      | 204 – blank pipe                  | 120                    |

The slot size should be recommended depending on the grain size of the granular zones as given below;

**Table 7 Slot opening size in different size of formation sands**

|                       |                                      |
|-----------------------|--------------------------------------|
| Fine sand             | : 1/64” (0.04 cm) to 1/32” (0.08 cm) |
| Medium to coarse sand | : 1/16” (0.15 cm)                    |
| Gravel                | : 1/8” to 1/16”                      |

Both the shallow as well deep tube wells should be artificially packed with gravels of size ranging within 2 – 3 – 4 mm and a bail plug of 2 – 5 m should be provided in order to the yield and life of the well.

**5.3 Water Conservation and Artificial Recharge:**

No such water conservation and artificial recharge structure has been constructed in the district.

**6.0 GROUND WATER RELATED ISSUES AND RELATED PROBLE**

No such major ground water problem exists in the district.

**7.0 MASS AWARENESS AND TRAINING PROGRAMME:**

One Mass Awareness Programme has been organised at Madhubani district head quarter. The numbers of participants were near around 500 including school children, school staff, general public, invited dignitaries, NGOs and media people.

**8.0 AREA NOTIFIED BY CENTRAL GROUND WATER AUTHORITY/**

**STATE GROUND WATER AUTHORITY**

Since all blocks of the district come under safe category from ground water development point of view, hence no area is notified either by Central ground water authority or State ground water authority till date.

**9.0 RECOMMENDATION**

- To have a detailed account of the aquifer characteristics in the study area, deep drilling along with pump test for estimation of aquifer parameter needs to be taken up.
- There is ample scope of large scale ground water development in the area to meet the requirement for agriculture sector. Exploitation of ground water can be done through Shallow tube wells and bamboo boring to meet the requirement of small and marginal farmers while deeptubewells can be operated through farmers cooperative.
- Energisation of pump needs to be taken which can help in increasing irrigation potential and cropping intensity.